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Brightness Engineering

By W. ROBINSON, B.Sc., A.M.I.E.E. *(Fellow)*

Summary

Brightness engineering at its present stage of development can be defined as the extension of illuminating engineering by adopting and producing limiting brightness ratios in interiors where comfortable and easy seeing are primary considerations. Further development hinges on the acceptance of a generalised brightness code, and two possible methods of establishing this are considered in the light of recent work on the subject.

Methods of brightness design using inter-reflection tables are described and the associated problem of brightness measurement is discussed. The field flux method of lighting design based on zonal flux distrubtion is compared with the brightness ratio method.

In the wider sense, brightness engineering involves prescribing and producing a good visual environment and offers to lighting engineers both greater scope and heavier responsibilities.

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(1) Introduction

Brightness engineering may be regarded as illuminating engineering extended to include the planning of brightnesses and brightness ratios. It is a new development in so far as it is an attempt to plan not only the illumination on a plane of reference but the brightness distribution of the entire field of view. If the premises on which it is based are sound, brightness engineering represents design for vision in its widest sense. It does not, however, represent a breakaway from existing illuminating engineering practice but rather a rationalising process. The methods of glare control at present used and the illumination of surroundings, combined with correct colour treatment, are brightness engineering applied by rule of thumb and the guidance of experience.

There are three conditions which must be met before brightness engineering can be accepted as practicable:—

(1) There must be agreement regarding desirable brightness ratios, i.e., some form of brightness code must be accepted.
(2) There must exist practicable means of predetermining brightnesses in an interior which take into account the effect of interreflections.
(3) The measurement of brightness must be as practicable as measurement of illumination is at present.

Even when the above conditions are satisfied it is still uncertain whether this extension of lighting technique is in the best interests of all concerned. In what follows this question is discussed together with reports on some of the outstanding developments in the subject.

The author is with the British Electrical Development Association. Manuscript first received on November 1, 1950, and in revised form on November 29, 1950. The paper was presented at a meeting of the Society held in London on January 9, 1951.

(2) Preliminary Discussions on Brightness Engineering

(2.1) Design Procedure

The result of any lighting installation is a brightness pattern, the nature of which hampers or assists the particular visual task. The illuminating engineer's job is to illuminate the area concerned so as to provide a good brightness distribution. The most usual procedure is to decide on the basic illumination, usually by reference to the I.E.S. Code, and then to prepare a layout which will produce this with suitable fittings. If the illuminating engineer is competent, and is allowed sufficient money, he will keep down the brightness of his fittings (or conceal them altogether), light up the ceilings and walls and generally avoid heavy contrasts. He will in fact arrive at a good brightness pattern, always provided that it is not spoilt by faulty decorations, or by vagaries of his client.

It will help to put the application of brightness engineering into perspective if we consider design procedure according to its principles. The engineer would decide to organise the brightness distribution in the interior according to a broad set of rules which lay down limiting ratios between the brightness of the work, its background and the general surroundings, and between the light sources and their background. Since the I.E.S. Code is based on the work-brightness necessary for good seeing he would start from there and prepare his layout as before, but at this stage he would determine from tables (similar to the Co-efficient of Utilisation Tables) the brightness of the top and middle of the walls, the ceiling, floor and work area, and would then check whether the resulting brightness ratios fell within the limits laid down for the particular application. The result of the check might be to confirm the provisional design or to indicate the need for revision of the layout or a different choice of fitting. The result would be a lighting installation typical of good practice, but arrived at more certainly and consistently than by present techniques.

Brightness design of this nature presupposes the existence of an agreed framework of recommended brightnesses and brightness ratios, and practical means of predetermining them. Considerable progress has been made recently in both directions, from the glare researches of Holladay, Hopkinson [1], Ward Harrison [2] and others, and the work of the Committee on Standards of Quality and Quantity in Interior Illumination (usually referred to as the S.Q.Q. Committee) set up by the Illuminating Engineering Society of America.

The first report of the S.Q.Q. Committee [3] suggests a generalised basis for a Brightness Code and is discussed in Section 3. It is opportune, however, before embarking on a study of this subject to consider the general question of the desirability and feasibility of such a code at the present stage of lighting practice.

(2.2) The Application of Brightness Criteria

It is often suggested that lighting installations designed in conformity with a brightness code will be dull and lacking in enterprise or imagination. This idea may arise out of experience with indirect lighting (applied by some on the assumption that it is capable of producing the best possible conditions even though other forms of lighting would often serve the purpose better). It should be stressed, however, that brightness ratio limitations have absolutely no bearing on the lighting methods used. They are intended to apply to the average brightness of substantial portions of the fields of view represented by the work area, the walls, floor, and ceiling. So long as the brightness distribution obtained falls within the limits specified, it is immaterial, so far as the Code is concerned, what lighting method is used. It should also be pointed out that the average brightnesses to which any code would refer are not necessarily uniform brightnesses. Thus there is no interference proposed with normal decoration or furnishing methods and the only difference between a patterned wallpaper and paint or distemper, as far as brightness engineering is concerned, lies in the need to

estimate an average reflection factor for the wallpaper. The introduction into a room of dark furniture, *objets d'art*, flowers, etc., and, of course, people, does not affect the basic principles of the brightness design. The aim of a brightness code should be to provide lighting conditions which have the best prospects of securing comfortable and easy vision for those using the room for its normal purpose.

It should also be remembered that the whole basis of the ratio method of brightness engineering in its present stage of development is that of comfort in seeing and it is reasonable to consider its application only to those interiors in which the occupants rely for their efficient and physical well-being on comfortable seeing. It is with these limitations in mind that brightness ratios are discussed in this paper, but the scope of brightness engineering is not necessarily limited to brightness ratios as is shown in Section 4.

(2.3) The Establishment Of Brightness Criteria

The proposals put forward by the S.Q.Q. Committee and discussed in Section 3 lead naturally to speculation as to the practical steps which might be taken to establish brightness criteria.

Two possible approaches towards establishing a brightness code suggest themselves. In the first a provisional set of limiting brightness ratios might be adopted within which a number of installations would be made. These installations could then be used as a basis for comparison with existing installations with the same general functions. In due course sufficient information, based on observational appraisal, might be accumulated to justify the introduction of a brightness code on a firm basis.

An alternative method is a rather more cautious one of making a series of brightness surveys of existing installations combined with critical reports based on visual appraisal and the satisfaction given over a reasonable period by each installation. This would provide information which might be capable of analysis and from which conclusions might be drawn as to the most acceptable brightness ratios.

This latter method has some disadvantages. To begin with there would be no focal point for the investigation. It is possible to appraise any number of lighting installations by comparing each with an appropriate reference installation, but it would be difficult to extract very much useful data from the mere comparison of installations one with another. Difficulties can be foreseen in deciding who would make the surveys and the analyses, and the results would involve considerable labour without necessarily leading to definite conclusions.

Adopting a provisional code on the other hand would provide opportunities for testing brightness design technique as well as the merits of the code. The installations so designed would provide material for criticism and a basis of reference for other installations. There need be no fear that the comparison installations would be unacceptable or "special" in any way except in being more rigorously planned.

Sufficient data is available, in the author's opinion, to enable a provisional brightness code to be drawn up and the next section reviews action already taken in the United States in this connection.

In view of the importance of this subject, and in view of the great contribution made by this country to the fundamental data which lie at the root of brightness engineering, it is urged that the initiative be not left to others. The Illuminating Engineering Society might well consider whether the production of a brightness code under its auspices would not be the logical sequence to its work on recommended illumination values.

(3) The Work of the S.Q.Q. Committee

(3.1) Brightness Limitations

The S.Q.Q. Committee was set up in America in 1943 to establish fundamental foundations for lighting practice based upon available experimental data pertaining to brightnesses and brightness ratios and all matters affecting visibility, comfort, and ease of seeing.

The Committee set to work on the assumption that experimental and observational results provided sufficient data for the establishment of a broad framework of limiting brightness ratios within which visual comfort, at least, could be assumed.

The Holladay glare formula based on the shock effect of a glare source, was adopted as a basis for preliminary studies of the upper limits of brightness of fittings beyond which discomfort must arise. A table (Table I) was prepared showing the relation between the illumination obtained, the actual brightness of fittings, and the

Table 1.

Brightness (B) of Glare-Sources for the Comfort-Discomfort Threshold.

Fitting	Lamp watts	Actual Brightness of fittings ft.-L.	Room 12 ft. × 12 ft. × 8 ft. One fitting at 6.5 feet		Room 30 ft. × 30 ft. × 12 ft. Nine fittings at 10 feet		Room 50 ft. × 50 ft. × 12 ft. Twenty-five fittings at 10 feet	
			*1m./ft.2	B (ft.-L.)	1m./ft.2	B (ft.-L.)	1m./ft.2	B (ft.-L.)
12 in. Diffusing Sphere	150	750	7.3	315	12.8	570	14.8	570
14 in. ,,	200	785	10.2	325	18.2	590	21.0	595
16 in. ,,	300	955	15.9	355	29.0	640	33.6	645
18 in. ,,	500	1280	27.8	400	49.1	715	57.0	730
14 in. semi-Indirect	200	370	8.0	315	14.7	570	17.0	600
16 in. ,,	300	455	13.2	345	23.4	625	27.2	650
18 in. ,,	500	610	23.0	390	39.6	690	46.0	715
16 in. Luminous Indirect	200	180	7.0	285	12.8	535	15.7	540
18 in. ,,	300	225	11.2	310	20.4	545	25	590
18 in. ,,	500	380	19.0	360	34.5	630	42.3	685
20 in. ,,	750	445	27.5	390	50.1	670	61.4	740
20 in. ,,	1000	645	39.9	435	72.5	740	89	825

* 1 lm./ft.2 = Actual illumination on work of 80 per cent. diffuse reflection factor. (These values must be multiplied by 10 if the work has a diffuse reflection factor of 8 per cent.)

limiting permissible brightness (from the Holladay formula) for three different sized rooms for a series of fittings.

By this means it was possible to compare experimental results with actual results over a very wide range of lighting conditions, and to draw certain conclusions such as the following:—

The illumination on the work is meaningless by itself. It is the brightness only which is significant.

In Table I the work is assumed to have a reflection factor of 0.8. If this were reduced the general lighting would have to be increased accordingly, thus destroying the correct relationship between work brightness and surround brightness. Supplementary lighting to maintain the basic work brightness is the better solution.

(3.2) Brightness Ratios

The Committee then considered brightness ratios as apart from limiting brightnesses, and from observational studies and a study of the various researches into the subject (particularly those of Lythgoe) prepared the following generalised code of brightness ratios:—

Brightness-Ratios to Attain Best Seeing Conditions:—

(i) The ratio of the brightness of the visual task to the brightness of its immediate surroundings is unity.

(ii) The brightness-ratio of a light-source or luminous portion of a luminaire to its background is unity.

Brightness-Ratios to Attain Good Seeing Conditions:—

(iii) The brightness-ratio of the visual task to its immediate surroundings should be no greater than three.

(iv) The brightness-ratio of a light-source, or luminous portion of a luminaire, to its background should not be greater than three.

In the notes accompanying these recommendations the following points are made:—

(a) The specifications apply to relatively large areas and do not involve purely aesthetic considerations.

(b) In recommendation (iii) the condition where the surroundings are brighter than the work is not included though experimental evidence appears to permit it. It is considered psychologically and physiologically preferable for the work to be at least as bright as the surroundings.

(c) In recommendation (iv) it is admitted that this is an idealistic figure and that higher ratios are often permissible. (See Table 2.)

Finally the Committee prepared a table (Table 2) showing the relation, as derived

Table 2.

Limiting Brightness of Glare Sources (Computed with Holladay's Formula).

Brightness in footlamberts (or footcandles on work with 100 per cent. Diffuse Reflection Factor).	Size of glare source in steradians			
	Q = 0.0001	Q = 0.001	Q = 0.01	Q = 0.1
	Equivalent projected area of glare source for distance of 10 feet.			
	1.44 sq. in.	14.4 sq. in	1 sq. ft.	10 sq. ft.
	Limiting Brightness (ft.-L.) for Comfort-Discomfort Threshold			
1	761	426	239	135
2	931	524	296	167
5	1231	693	391	222
10	1525	860	486	275
20	1880	1070	605	347
50	2520	1425	822	482
100	3140	1835	1057	635
	Brightness ratios (given by B/5F)for Pleasant-Ideal Conditions			
1	152	85	48	27
2	93	52	30	17
5	49	28	16	9
10	31	17	10	6
20	19	11	6	3
50	10	6	3	2
100	6	4	2	1

Fig. 1a. Brightness distribution in a well-lit drawing office.

from Holladay's formulae, between work brightness and glare source brightness for various sizes of light sources.

Report No. 1 of the S.Q.Q. Committee [3] represents the first attempt to co-ordinate experimental and observational data into a brightness code. Objections may be raised, not so much to the methods used as to the assumptions that have had to be made.

It will be seen, from Table 2, that though Holladay's formula is based on limiting conditions only it has been used (by the use of a safety factor of 5) to prescribe ideal brightness ratios. It is open to doubt whether brightness ratios arrived at in this way can be regarded as other than very broad approximations.

It is admitted by the Committee that the brightness ratio recommendations are somewhat idealistic. A generalised code such as this could hardly be otherwise since a high safety factor is necessary where there is not 100 per cent. certainty about the basic data. If greater latitude were allowed there would be a danger of the code encouraging something poorer than the best existing practice.

It is interesting to notice a tendency, both in this country and in America, to think in terms of a general 3 to 1 brightness ratio which has the effect of limiting the ratios of all contiguous areas in the field of view and which thereby acts to control the decoration colours used throughout the interior. Even though this might be considered to be over-simplified it may well form, in conjunction with a table limiting the brightness of fittings, the starting point of a provisional code.

Figs. 1a and 1b show the brightness distribution obtained in two offices whose lighting and decorations were designed without the employment of brightness data. The fact that the result is in general conformity with the 3 :1 ratio recommendations indicates how small is the gap to be bridged between good illuminating engineering and the ratio method of brightness engineering.

(3.3) The Predetermination of Brightness and Brightness Ratios

The 3rd and 4th Reports of the S.Q.Q. Committee ([4, 5]) relate to the evolution of inter-reflection data from which brightnesses of the parts of an interior can be obtained having regard to inter-reflections between the interior surfaces.

The Committee based its studies on the early work of Buckley([6]), Yamauti([7]) and Hisano([8]) and on the inter-reflection equations for rectangular interiors developed by Parry Moon in 1941([9]). D. E. Spencer undertook the task of developing the inter-reflection method and computed the basic inter-reflection tables. The calculated results were compared with actual measurements previously made by Meacock and Lambert([10]) on a model light well, and further checked by Hisano in rooms of various shapes. The tables agreed with observations to within 12 per cent.

The inter-reflection method can be regarded as an extension of the Harrison and Anderson lumen method of design ([11]). In the lumen method of design the room proportions are accounted for by a Room Index Letter obtained from tables of room sizes. The percentage of lamp light which escapes absorption by lighting fittings and room surfaces is obtained from co-efficient of utilisation tables which take into account the room dimensions, colouring, and the efficiency and distribution of the fittings. The tables give utilisation co-efficients for a horizontal plane since this is normally required but they could be adapted to suit any plane of reference if the complicated sets of tables involved served any useful purpose.

In order to prepare inter-reflection tables it is necessary to know the proportion of light flux (direct and inter-reflected) which reaches the major room surfaces: ceiling, top of the walls, half-way up the walls, floor, and working plane; and a feature of the Inter-reflection Method is the comparative economy of tables by which this is done.

The preparation of the tables is simplified firstly by the fact that the percentage light absorption is a function of the proportions of an interior and not of its size, and

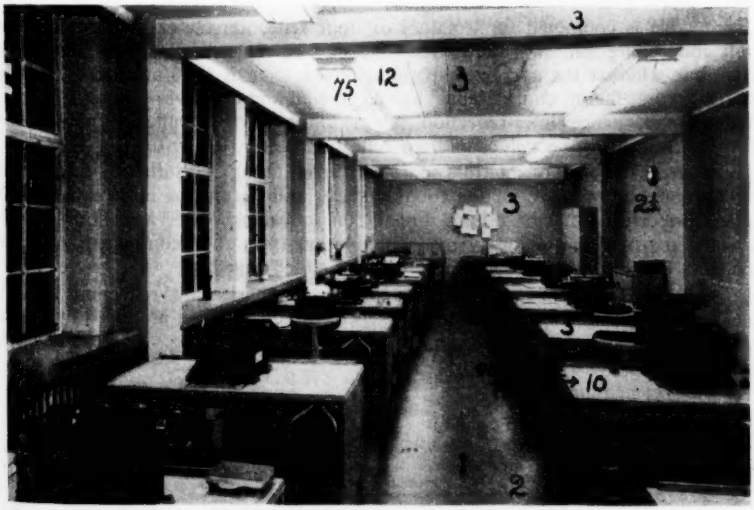

Fig. 1b. Brightness distribution in a well-lit typists' office.

secondly that the percentage absorption in a room of any shape can be given in terms of an equivalent square room by use of a room co-efficient, K_r, such that

$$K_r = \frac{h\ (w\ +\ l)}{2\ w\ l}$$

where h = room height
w = room width
l = room length.

$K_r = 1$ for a cubical room and becomes h/w for a square room. Thus a room of length 40 ft., width 20 ft. and height 10 ft. has a room co-efficient

$$K_r = \frac{10\ (20\ +\ 40)}{2\ (20).\ (40).} = 0.375$$

This room has the same room co-efficient (and hence co-efficient of utilisation) as a square room 10 ft. high and 26.7 ft. square since

$$K_r = 10/26.7 = 0.375$$

In computing the basic tables it was necessary to consider three simplified special cases of room lighting.

(1) All light flux coming from the ceiling alone.

(2) All light flux coming from walls alone.

(3) All light flux coming from floor alone.

The assumption was also made that walls, ceiling and floor have uniform reflection factors of $\rho 1$, $\rho 2$ and $\rho 3$ respectively.

A set of tables was then provided for each of the three basic lighting arrangements, ceiling, wall and floor lighting, each set giving brightnesses for the

Top of wall (B_I), middle of wall (B_{IM}), ceiling (B_2), and floor (B_3).

The brightnesses are expressed in the tables as the proportion of the brightness without inter-reflections of the walls (B_{01}), ceiling (B_{02}), or floor (B_{03}) according to the basic lighting considered.*

Each table is computed for 2 values of floor reflection factor with combinations of wall and ceiling reflection factor for values of K_r between 0 and 2. It will be noticed that, whereas the average horizontal illumination is little affected by changes in floor reflection factor, considerable changes in wall and ceiling brightness may occur from this cause, hence inter-reflection tables differ from co-efficient of utilisation tables in allowing for two values of floor reflection factor, 0.1 or 0.3.

In the great majority of interiors some light from fittings falls directly (i.e., without inter-reflections) on to many of the room surfaces and before the basic tables can be used the proportion of light falling directly on to ceiling, walls and floor must be known and the brightnesses or average illumination from each component separately computed. The individual results must then be added together.

To reduce the labour involved in applying the basic inter-reflection tables to practical lighting installations, a further six sets of tables has been produced by Spencer and incorporated in the Fourth Report of the S.Q.Q. Committee. These tables refer to the following types of lighting :—

(1) Indirect lighting.

(2) Trough lighting.

(3) Wall lighting.

(4) Direct lighting.

* Brightness arising from direct overhead lighting which is totally incident on the floor is obtained by calculating the intrinsic floor brightness B_{03} (ignoring inter-reflections) and then applying the *Floor* Lighting tables.

(5) Combined wall and ceiling lighting.
(6) Lighting with diffusing globes.

In considering these tables the following symbols are used:—

f = interflectance = (lumens to working plane)/(lumens from fitting).
K_u = Co-efficient of utilization = (lumens to working plane)/(lumens from lamp).
S = Area of working plane.
g = Efficiency of lighting fittings.
F_L = Total luminous output of lamps.
E_{av} = average illumination on working plane.

The tables take the same general form as the basic tables but give information in different terms, viz., one table in each lighting category gives f (interflectance), while other tables give ratios

$$B_{IT}/E_{av},\ B_{IM}/E_{av},\ B_2/E_{av},\ \text{and}\ B_3/E_{av}\ \text{in each category.}$$

A typical inter-reflection table is shown in Table 3.

The procedure for predetermining brightnesses and illumination is then as follows:—

(a) From co-efficient of utilization tables, obtain illumination from the expression

$$E_{av} = \frac{K_u F_L}{S}$$

or obtain illumination from inter-reflection tables by the expression

$$E_{av} = \frac{f\ g\ F_L}{S}$$

(b) Then obtain values of B_{IM}, B_{IT}, B_2 and B_3 from the relevant tables.

Inter-reflection tables of this type now form part of standard lighting data in the U.S.A. and are included in the Lighting Calculations section of the American I.E.S. Handbook. Work has also been done on the preparation of inter-reflection tables giving

Table 3.

A Typical Inter-reflection Table.

Average Ceiling Brightness (B_c)/Average Illumination level (E_{av})
Direct Lighting

Ceiling Reflectance r_c	0.8			0.7			0.5		
Wall Reflectance r_w	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
Room Coefficient K_r	Floor Reflectance r_f = 0.3								
0.1	0.261	0.238	0.216	0.223	0.204	0.185	0.149	0.136	0.123
0.2	0.266	0.221	0.180	0.226	0.190	0.154	0.151	0.127	0.100
0.3	0.271	0.212	0.153	0.232	0.181	0.131	0.154	0.121	0.087
0.4	0.283	0.208	0.134	0.243	0.178	0.115	0.162	0.118	0.076
0.5	0.299	0.210	0.120	0.257	0.180	0.100	0.171	0.120	0.069
0.7	0.345	0.229	0.108	0.296	0.196	0.092	0.197	0.131	0.062
1.0	0.450	0.294	0.118	0.380	0.252	0.100	0.257	0.168	0.068

The above data are extracted from the I.E.S. (America) Lighting Handbook.

Table 4.

Office Lighting—Brightness Analysis.

DATA. Room dimensions 40 ft. x 30 ft. x 12 ft. high.

$$K_r = \frac{12\ (30+40)}{2 \times 30 \times 40} = 0.3$$

Illumination—20 lm./ft.$_2$

	Brightness (Ft.-L)						Brightness Ratios				
	Walls		Ceiling	Floor	Work	Light Source					
	B_{IT}	B_{IM}	B_2	B_3	B_w	B_s	B_w/B_{IM}	B_w/B_2	B_2/B_{IM}	B_s/B_2	B_s/B_{IT}
(*a*) *Direct Lighting* Walls $\rho_1=0.3$ ... Ceiling $\rho_2=0.8$ ... Floor $\rho_3=0.1$ ...	5	4	2½	2	16	1000 (i)	4 : 1	6½:1	2/3:1	over 400:1 (iii)	over 200:1 (iii)
(*b*) *Direct Lighting* (ii) Walls $\rho_1=0.5$ ... Ceiling $\rho_2=0.8$ ... Floor $\rho_3=0.3$ ...	8½	7	5½	5½	16	over 1000	2 : 1	3 : 1	2/3:1	200:1 (iii)	120:1 (iii)
(*c*) *Indirect Lighting* Walls $\rho_1=0.5$ Ceiling $\rho_2=0.8$ ... Floor $\rho_3=0.3$ ...	8½	7	27	5	16	27	2 : 1	1:1.6 (iv)	4 : 1 (v)	—	4 : 1
(*d*) *General Diffusing* Walls $\rho_1=0.5$ ... Ceiling $\rho_2=0.8$ ... Floor $\rho_3=0.3$ ...	10	10	15	6	16	over 1000	below 2 : 1	1 : 1	below 2 : 1	over 60 : 1	120:1 (vi)

The reflection factor of the work is assumed to be 80 per cent.

Notes :— (i) Assumed figure for fluorescent trough reflector.
(ii) Increased reflection due to :—lighter furniture, lighter floors, light coloured window coverings.
(iii) Can be considerably reduced by louvering or concealing fittings.
(iv) Ceiling is brighter than work and likely to be distracting.
(v) Too high for sustained comfortable vision in view of large ceiling area.
(vi) Pendant fittings are most often seen against walls as background ; ratio too high if spheres are used in view of large total area of fittings. Reduction of this ratio may be difficult and expensive.

more precise data for particular types of lighting fittings, and there is little doubt that tables giving accurate brightness data covering a wider range of lighting installations will become available in due course.

(3·4) Lighting Design Using Inter-reflection Tables

Inter-reflection tables may be of great assistance in lighting design, particularly under the guidance of a brightness specification. The current tables relate to the six general cases outlined in Section 3, and providing the installation falls into one of these conventional categories the information is sufficient to give general guidance to the designer. When tables are available covering a greater range of layouts and fittings the scope and precision of brightness design will increase, but for the present they are best used as a preliminary design check. For this purpose it is only necessary to know the illumination required, the room dimensions, and the actual or estimated room surface reflection factors. The average brightnesses arising from the particular method

of lighting under consideration, and the effect of changes in reflection factor of the work or decorations can be analysed as in the following example. Even if there is no brightness code the information given by regular brightness analysis will eventually accumulate into very useful design data.

(3.5) A Preliminary Brightness Analysis

Table 4 shows the brightness distribution obtained by reference to current inter-reflection tables in a hypothetical office whose dimensions and surface reflection factors are known and which is to have an illumination of 20 lm/ft.^{2}.

If a limiting 3 : 1 brightness ratio of illuminated surfaces is used as a guide together with a limiting source/background ratio on the lines suggested by Petherbridge and Hopkinson (Table 5), or a source/work brightness ratio as Table 2, the ratios obtained can be compared and deductions made as below regarding the type of lighting system likely to be most suitable.

Case A. Walls and ceiling too dark; Source brightness excessive. Reflection factors of surroundings too low.

Case B. Walls and ceiling satisfactory; source too bright. Installation will be satisfactory if source brightness is reduced by louvres or other means. (See Table 2 or 5.)

Case C. The ceiling is brighter than the work and is more than three times as bright as the walls. Additional lighting on walls and work would be necessary to rectify matters.

Case D. The installation is satisfactory in every respect except that of excessive brightness of fittings (in view of the size of light source (Table 5)). Little can be done about this in the normal way though it would help to use dished fittings, which have a smaller apparent area at the normal viewpoint than, say, diffusing spheres.

The design can now be proceeded with along normal lines and with regard to the pitfalls which the analysis has revealed.

The above observations, though arising from purely theoretical considerations, agree well with the author's experience and appear to confirm what has already been suggested, namely that brightness engineering is no more than good lighting practice under the guidance of rules as well as experience.

(4) The Field Flux Method of Lighting Design

Some reference should be made at this stage to the very interesting work of H. L. Logan ([12]) in America culminating in what is known as the field flux method of lighting design. In an effort to ascertain the ideal luminous environment Logan

Table 5.

(Petherbridge & Hopkinson's Data).

Ratios of Brightness of Source and Brightness of Environment for Different Degrees of Discomfort Glare (based on 14-in. spheres) ([1]).

Brightness of Source (candles sq. in.)	Ratio of Source Brightness/Surround Brightness for :—			
	A Just Intolerable Glare	B Just Uncomfortable Glare	C Just Acceptable Glare	D Just Imperceptible Glare
0.5	1,130	251	54	13
1.0	755	197	41	10
2.0	532	151	29	7.5
5.0	389	108	19	5.2
10.0	302	81	13	3.8

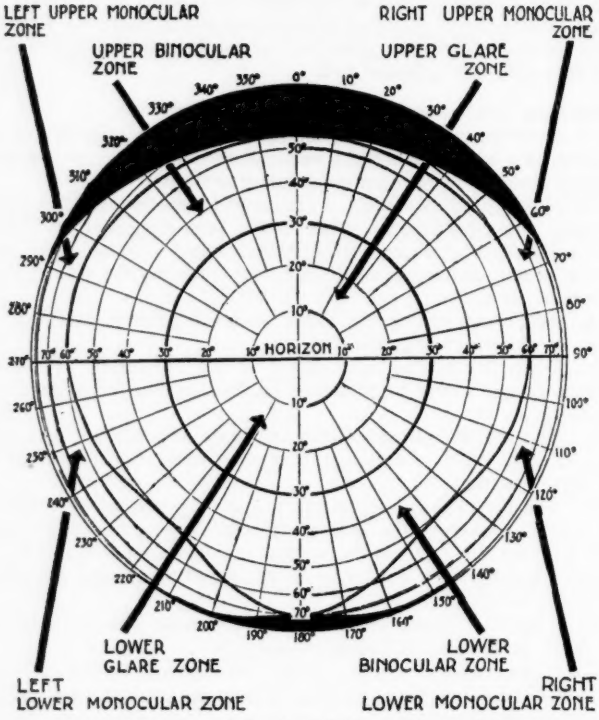

Fig. 2. The zones of the visual field according to Logan.

examined in detail the visual patterns in those parts of the earth considered most kind to human life (the areas in the neighbourhood of the 70 deg. F. isotherm).

He divided the field of view into zones (Fig. 2) and studied the light flux from each in many different situations. In order to measure the light flux from each zone he devised an ingenious instrument (Fig. 3), in which a virtual image of the field of view, covering 180 deg., was formed in a convex mirror of special contour. This virtual image was imaged by an optical system on to a photovoltaic cell, over which diaphragms were arranged so that the light flux could be measured in various zones in the field of view. The cell was connected to give a spectral response approximating to that of the CIE standard observer.

A chart was then prepared on which the field of view was represented by a rectangle in which vertical rectangular divisions represented the areas of the special zones of the field of view. Horizontal ordinates were drawn to enable the relative amounts of luminous flux in each zone to be compared. Fig. 4 shows the flux diagram according to Logan of conditions to which man is most closely adapted.

Logan then proposed methods of preparing flux diagrams both for existing interior lighting installations and contemplated installations. These could then be compared with the ideal conditions with a view to adjusting either the existing installation (or interior) or modifying the design in a new installation.

The field flux method is a departure from the brightness ratio method of design

and is based on the mean field flux received from zones of the visual field. Logan does not dispute the importance of brightness ratios for lighting comfort but considers that other factors are involved in completely satisfactory lighting. In his view all the factors are contained in certain conditions of natural lighting. He therefore sets out to organise a visual field on the basis of the amount of light flux reaching the eyes from six selected zones. In other words he is concerned with ranges of intensity in fixed visual zones, whereas the ratio advocates are concerned with brightness ratios of more or less fixed actual areas.

The areas embraced by Logan's zones are only fixed at a given line of sight and design is based on this. The ratio method gives prominence to the working field of view but establishes comfortable conditions at any viewpoint.

Whatever may be the comparative merits of the two schools of thought there is no doubt that the brightness ratio method is capable of more general application than the field flux method though situations can be visualised when the field flux method has great possibilities.

The premise that civilised man is better adapted to outdoor natural lighting conditions, and that they are therefore the best criterion is one often advanced but has not been subjected to any scientific investigation. It is admitted, however, that for many lighting applications the quality of emphasis (field flux) may be as important as that of comfort (brightness ratio) and to that extent the field flux method of design can

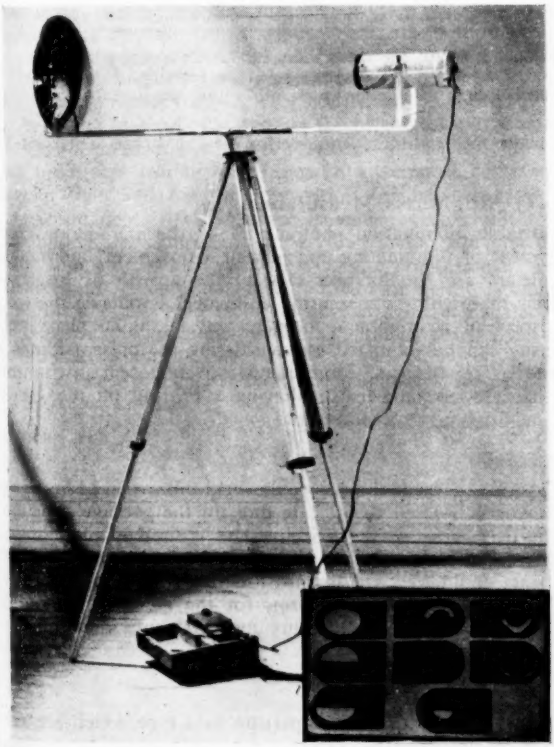

Fig. 3. The Logan flux meter for outside use showing diagrams for zonal measurements.

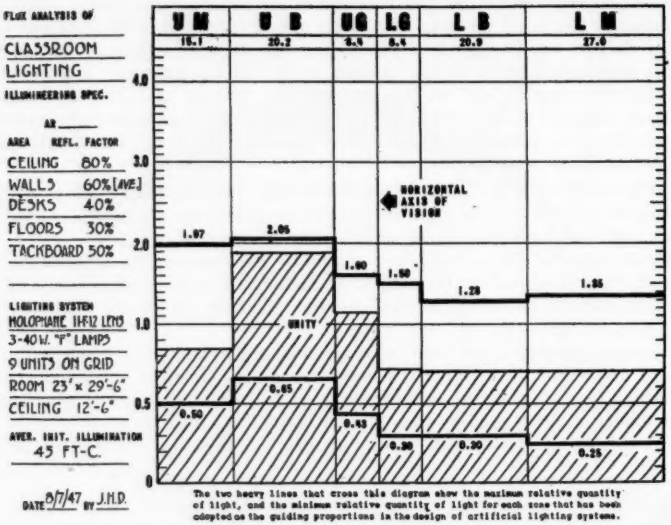

Fig. 4. Flux diagram for an interior. The heavy lines represent the upper and lower limits of relative flux from the various visual zones considered acceptable. The shaded area indicates the flux distribution of an interior which falls within the limits proposed.

be regarded as having a place in brightness engineering in the broad sense of the term.

(5) Brightness Measurement

The convenience of portable illumination photometers has been a major factor contributing to the development of illuminating engineering. Convenient and reasonably accurate brightness meters are equally necessary to the growth of brightness engineering. A major review of brightness measuring equipment is outside the scope of this paper but the prospect of a brightness measurement taking its place in the routine of lighting engineering can be estimated by considering the present trends in brightness measurement and by reference to some comparatively recent instruments which are instanced only because of some feature having a bearing on the general problem of achieving routine brightness measurement.

(5.1) Physical Brightness Meters

Photoelectric instruments can be used to measure the light flux received in a given zone of acceptance and can be calibrated to indicate directly the average brightness of the area from which the light is received. This method is used in photographic exposure meters where the acceptance angle is fixed and the area covered is fairly extensive. Similar instruments could be used to measure the average brightness of large areas but are not practicable, in portable form, for the measurement of the brightnesses of small areas. Apart from zonal flux measurements they offer no immediate solution to the basic problem.

(5.2) Visual Brightness Meters

There are several brightness meters of the comparison field type which are sufficiently accurate and are not difficult to use. The common principle is to employ a

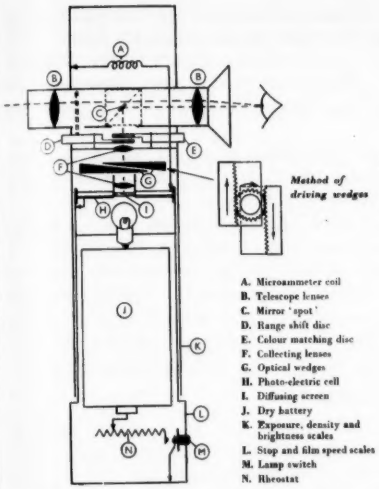

Fig. 5. Schematic diagram of a brightness meter incorporating photo-voltaic calibration.

comparison field whose brightness can be adjusted, by means of a lamp, to match the brightness of the test surface which is simultaneously viewed.

There are many variations of this theme, mainly in respect to :—

(a) Sizes and shapes of comparison and test fields.

(b) The use of focusing eyepiece lenses.

(c) The method of stabilising the brightness of the comparison field lamp.

One American instrument employs a standard type of illumination meter to give brightness readings by using an attachment consisting of a box with a direct viewing hole and the usual provision for balancing the field with an illuminated comparison field. The balance is made by controlling the brightness of the lamp illuminating the comparison field. In use the attachment is placed over the light-meter, the cell of which receives a definite proportion of the light output of the comparison lamp. The attachment is matched to the lightmeter so that the brightness in foot-lamberts is read from the normal lightmeter scale. Filters are used to enlarge the range of the instrument and the lightmeter scale readings are multiplied or divided by the filter constants.

Another type (Fig. 5) embodies a light-sensitive cell to stabilise the brightness of

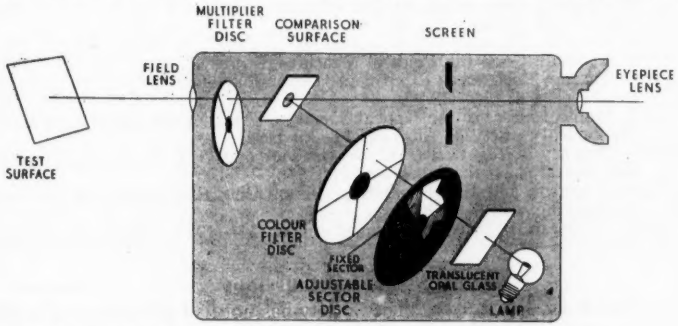

Fig. 6. A general purpose brightness meter (schematic arrangement).

the comparison lamp during the observation. The brightness of the comparison field is adjusted by variable density filters interposed between the lamp and the field. The comparison field is very small and consists of a spot which appears at the centre of the test field which is imaged in the eyepiece. This small field is very convenient for spot brightness measurements of light sources, etc., within the range of the instrument and facilitates the task of getting a match.

Fig. 6 shows another well-known form of brightness meter in which the comparison field is viewed in the centre of an annular test field. In this type calibration is effected by comparison with a surface of known brightness.

Other instruments are available with their own special features, many of them adapted to special purposes and varying in accuracy and complexity accordingly.

It is not intended here to do more than introduce the subject of brightness measurement facilities as a very necessary adjunct to progressive lighting practice. It would be optimistic to state that brightness meters can now take their place alongside pocket lightmeters but once their usefulness is recognised there seems to be every prospect of their becoming available in reasonable sizes and at reasonable prices.

(6) Conclusion

The material presented in this paper is neither original nor new. Views expressed therein are those of the author as an individual. They are expressed because discussion springs more readily from an expressed viewpoint, and not because the author claims any particular qualification for doing so. The terms of reference applied to brightness engineering here are narrower than many of its adherents are likely to accept, and were chosen to keep this summary within reasonable bounds.

There are many viewpoints to be reconciled and many problems still to be solved before brightness engineering takes its proper place as a standard component of lighting engineering. The least of these are the technical ones; most are economic: but the greatest problem of all lies in the indifference of the great majority of the users of light to their own visual needs. The time may come when lighting engineers will habitually prescribe as well as dispense lighting. At the moment we might as well face the fact that too much of our work lies in competent dispensing and too little in prescribing. By accepting the fact that a prescription for vision is a brightness prescription we equip ourselves for this larger responsibility. In that lies the wider definition and scope of brightness engineering.

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Discussion

DR. R. G. HOPKINSON: The Society has not had the subject of brightness engineering brought up for discussion before and we should be grateful to Mr. Robinson for

sorting out the vast mass of the literature and presenting the essentials in a concise form. In fairness he should have called his paper "Brightness Engineering in the U.S.A."

What I believe to be the first real brightness engineering was the street surface brightness work by the team under Sir Clifford Paterson at Wembley, with Mr. Waldram as its prime mover. This work started from the demonstration that the street surface forms the visual background against which all objects in the streets are seen. It then progressed through the measurements of road surface reflection characteristics, to the calculation of the optimum polar curve for a street lighting unit, thence to the design of units to give this form of light distribution, the proper positioning of units in relation to the configuration and the curvature of the road, and finally to a method of estimating the revealing power of the completed installation. That was brightness engineering.

By contrast, the American work seems to be too arbitrary in its approach. The very bulk of the published work demands that we discriminate in our selection of what to study and what to leave alone. Three investigations seem to me to be well worthy of study. Firstly, Moon and Spencer's work on inter-reflection in rooms stands on its own merit apart from its link with brightness engineering. It is valuable for itself and the tables should be republished in this country for general use. Secondly, Ward Harrison's work on glare factors, although in need of revision in the light of recent work, both here and in the United States, is a valuable contribution to glare technology, and might well form the basis of an International Code. Finally, the experimental studies of Luckeish must command attention.

The "three-to-one ratio" work does not seem to me to depend on a sufficient body of experiment. It appears to have been derived in the first place on what may be a misconception of the significance of the work on visual acuity which was done by Lythgoe in this country. Recent experiments at the Building Research Station confirm that such restricted ratios of brightness are not necessary for comfortable vision, and common sense tells us that they must lead to miserably abstemious and drab lighting. Good lighting must have sparkle.

The field flux work of Logan is a novel and original approach to the lighting problem and is worth watching as it may conceivably lead to something of very real value, if the ideas are properly developed.

If we criticise the American work, we ought to offer something in place of it. Can we do this? I think we can. Paterson, in his Guthrie lecture as long ago as 1937, forecast the route which we in this country had intended to follow at that time. We had recognised that it is not so much the luminance as the luminosity which is the significant factor in governing the excellence of an installation. We were therefore examining methods by which we could plan the luminosity of our installations, and several papers were read before the Society at that time on the assessment of brightness and contrast. Provided we can plan our lighting in terms of what we actually see, we should be able to do for general lighting what was done for street lighting. Since the interruption caused by the war, this background knowledge has been used for the planning of the lighting of art galleries, where the luminosity of the pictures is all important, and it does seem to work. We are, however, a long way behind the Americans in devising a technology but, given time, I have no doubt that we shall succeed. We must, however, recognise with gratitude the vigour of our American colleagues, and hope that international co-operation will lead to the achievement of a lighting code which recognises the importance of the general environment as well as of the working plane.

MR. W. R. STEVENS: The author is right to emphasise the need for experiment on full scale installations. Lighting engineers have long been familiar with the fact

that brightness is more important than illumination, but although we have all paid lip service to this concept few of us have really thought in terms of brightness. Now we are faced with suggested luminance values and ratios which, if we are not careful, might slip into recognised practice whether they are good, bad or indifferent. Few things would be as conclusive as a valid proof of the correctness of any suggested values in full scale trials; but how are such trials to be made?

The author suggests "critical reports based on visual appraisal and the satisfaction given over a period." If we are to base our criterion on the opinion of the users of the installation over a long period we must be able to hold constant all the variables during that long period, and this as we well know is so difficult that it has rarely been done in the past. Even the changes in visual effect accompanying changes in illumination of the task are difficult to measure, although one would have thought this a much simpler matter than the correlation of visual effect and luminance ratios in the surrounds. There are a few classic experiments—Weston and Taylor on Type-setting, Adams on Tile-pressing and so on—but these are outstanding successes in a long period during which we have not yet found an accurate or convenient tool for determining change in visual efficiency with change of lighting conditions.

One says this in spite of the work of Luckeish and his colleagues, and those others who have investigated the value of blink rate and pulse rate, and the like. One of our greatest needs still is this accepted criterion by which we may gauge the effect of changes in a lighting installation.

If we have no such gauge how are we to compare installations having different brightness patterns? The author makes one other suggestion, namely critical visual appraisal. But our difficulty here is that almost certainly we shall appraise the installation by the very criteria upon which we have based our agreed brightness pattern. We shall draw upon known laboratory work—such as that of Lythgoe—in order to decide what we think ought to be good in an installation and then we shall judge the installation against those same decisions. The process will be as impossible and invalid as measuring a yardstick against its own length.

I am with those mentioned by the author who feel that existing brightness codes will lead to monotony. For example, the Office Lighting Code of the American I.E.S. suggests that the maximum luminance ratio between the lighting fittings and any part of the room should not be more than 40 to 1 and also suggests the fitting luminance should be not more than 400 ft.-L. Taking these figures, the minimum room brightness in the field of view must be 10 ft.-L.; but if the illumination is 20 lm/ft.^{2} falling on white paper of reflection factor 0.8, presumably any other part of the field of view must have a reflection factor of less than 0.4. I cannot help feeling that such uniformity in brightness would be not only restrictive but unnecessary and unpleasant. Are we really at our best inside a white painted spherical integrator? Possibly, but it is hard to believe.

MR. J. G. HOLMES: The author has made a plea for the acceptance of a "Brightness Code" as a development from the I.E.S. Code, which deals mostly with the illumination of the visual task, but he has not given a clear statement of the difference between these two types of Code and I think this is essential in a review paper on this subject. The "Brightness Code," as we have come to recognise, is based on "comfort and ease of seeing," whereas the I.E.S. Code of values of illumination is based on visual performance as defined and measured by H. C. Weston. It is well known in other spheres that comfort and hard work do not usually go together: comfort is essential to rest and relaxation as illustrated by slippers and easy chairs, but hard work requires more stimulating or compelling conditions, associated with discipline and business-like surroundings. I am sure that the same is true of the visual surround and that a brightness distribution which makes for visual ease and comfort

is not necessarily conducive to visual work. For example, I do not accept the general application of the S.Q.Q. recommendation of uniform brightness of the visual task and its surroundings, and of the light source and its background, for best seeing conditions over a period of time—I have worked for hours in such conditions in a large white Ulbricht cube (photometric integrating cube) and I have suffered slight nausea and considerable impatience after the first pleasant reaction to freedom from shadows had worn off. The same conditions may be experienced when walking on snow in a fog; the visual task is to find the path, which has much the same brightness as the remainder of the field of view, and many of us know that such an experience may be interesting and free from eye-strain for a short time but it rapidly becomes monotonous and tiring. I am convinced that the proper criterion for choosing a brightness distribution is not comfort or acceptability but is more related to interest and "workability."

The S.Q.Q. recommendation of 3:1 maximum brightness ratio has been endorsed in principle by Moon and Spencer, but it is not clear to me how rigidly the recommendation should be applied. Some three years ago, I set up a room about 12 ft. x 20 ft. in which it was fairly rigidly applied and the visual conditions were dreary in the extreme. We marked some reference points with large black crosses to assist in reading the photographs and these, with a brightness ratio of about 20:1, were the most pleasant feature of the room.

Another example of a troublesome brightness distribution occurred in the hot summer of 1940, when a medical friend told me of a case which he had diagnosed as "snow-blindness." The sick man was a plaster worker and he spent his working hours with his work, the bench (the immediate surround) and the floor (the more remote surround) all covered in white powder of reasonably uniform brightness. The upper half of his field of view consisted of a blacked-out window, rather dirty walls and an opaque reflector lighting fitting which directed most of the light on to the floor. As a result, the man received very little flux from the upper hemisphere and a lot from the lower, and he complained of headaches, nausea and giddiness. We put matters right by a coat of whitewash on the window and walls and by a translucent reflector on the lamp, and he quickly and completely recovered. We had reduced the brightness ratios from high values to perhaps 20:1 but, more important, we had restored the balance between upper and lower hemispherical flux. This balance of total flux from different parts of the field of view, or the balance of the "bulk brightness" of large areas of the field, seems to me much more important than the ratios of brightness of adjacent areas, but the optimum distribution of "bulk brightness" in the whole field is very difficult to define because one can become accustomed to such a very wide range of distributions. The work of H. L. Logan in America has given some clue to this method of brightness engineering and the results which he has shown in practical installations have justified the considerable amount of labour in developing his technique. His work indicates, for example, that the flux reaching the eye from above the line of sight should average about 60 per cent. of the total flux and that this ratio should lie between 30 per cent. and 85 per cent. In his diagrams brightness ratios of about 10:1 are allowed from one large area to another and Logan would actually expect brightness ratios up to perhaps 50:1 between one small part of the field and another without any unfortunate results. Ward Harrison and Meaker, too, do not exclude large local brightness ratios from installations which are rated as acceptable.

Variety in colour and texture may help considerably in making a 3:1 scheme workable and acceptable over a long period, but there must be some wide variations in the brightness of small objects to give a lively appearance to the visual field. In practice we rarely get large areas of substantially uniform brightness and we nearly always get gradations of brightness; I believe that the most promising prospect for

brightness engineering lies in the proper choice of brightness gradations and of the distribution of bulk brightness or field flux.

MR. R. O. ACKERLEY: I wonder whether the argument between the American people who suggested these very low brightness ratios and those of us over here who think differently, does not mean that we are talking at cross purposes. I understand that the American tables refer only to large areas and to the average over an area. Mr. Holmes has referred to his experiment in which he put black paper crosses on the walls and how it improved the situation. Possibly if he had put black adhesive crosses at six-inch intervals all over the wall, or even pink crosses, it would have made an even better job of that wall, and the average brightness over the area might have been within the brightnesses suggested by the Americans.

Are there not two lines of investigation in this matter: one, what are the maximum overall brightness ratios which are desirable; and the other, what is the minimum overall brightness variety which is desirable within the broad areas?

MR. S. S. BEGGS: Mr. Robinson has referred to the flux method of Logan in some detail, but does not give much information on other methods that have been proposed. I should have liked more guidance on the value of these different methods.

If, in the inter-reflection table quoted, a value between .15 and .20 were adopted for the quantity $B_c/E_{av.}$, over the very wide range of conditions covered by this table the error would be within a factor 2:1. Remembering the uncertainty of the values to be assigned to quantities such as the wall, ceiling and floor reflectances, and the departure that occurs in practice from the idealised assumptions of the theory, the use of precise tabulated data appears to be an over-refinement.

Use should be made only of general round figures (e.g. 0.2 for $B_c/E_{av.}$) for approximate calculation if and where such is necessary.

What is required is a more practical and straightforward approach, by the formulation of broad guiding principles (e.g. the avoidance of extreme contrasts), but the 3:1 ratio as the maximum permissible in a room appears patently absurd from one's experience.

MR. J. M. WALDRAM: There may be criticisms of the American work on brightness engineering, but we must give them great credit that they have explored the subject and produced some concrete proposals. There is, after all, something to be said for the philosophy of drawing up a recommended practice before one has learned all about a subject, for in that way experience can be gained—provided always that it is recognised that the recommended practice is itself exploratory.

In each of the American proposals there is an assumption at the beginning, and upon that assumption a large structure is erected. In studying the proposals it is the initial assumption rather than the structure which should attract our attention. The proposals of the S.Q.Q. Committee, based upon Holliday's work, set out to avoid visual shock when the subject looks at the lighting fittings; Ward Harrison's work is specifically upon glare and refers to a subject looking up from his work to a horizontal line of sight; Logan's work is based upon the characteristics of the visual field which occur outdoors in certain localities; Luckeish's proposals refer to the borderline between comfort and discomfort, and so forth.

Some of these bases may be criticised because they over-simplify the problem, and most of them because they do not go far enough. It is remarkable that they all, in one way or another, are based upon the comfort of the subject. Comfort is generally a good thing, but it is not the only thing. Too much comfort, pursued for its own sake, is never a good thing; one can become a kind of visual sybarite. There are other characteristics of the visual field which have also to be studied; for we need

exhilaration and direction as well as comfort. I refer particularly to the characteristics of emphasis and modelling. If you limit the brightness ratios throughout the interior you automatically and simultaneously limit the possibilities of modelling and emphasis, and to some extent the glare; these quantities are all interlocked, and it is not possible to fix one without regard to the others.

It may be for this reason that some of the proposals made hitherto have been criticised. The 3 : 1 ratio so-called has sometimes resulted in very flat and uninteresting interiors; I recall one store in which I went from point to point seeking some relief from the uniformity, and trying in vain to find a highlight somewhere in which I could examine the goods in my hand.

At this point I join issue with Mr. Robinson, for he said in presenting the paper that in his view the lighting engineer was unconcerned with such matters as decoration. Dr. Hopkinson has referred to the earliest completed work on brightness engineering, the work in this country on street lighting. From the course of that work there are. I suggest, two lessons to be learned. The first is that it was inspired by a study of anomalies. If we find that some proposal has led us to an absurdity, it is at that point that there is something to be learned, for our theory is manifestly wrong or incomplete. The second point is that the work on street lighting hinged upon the study of the " decorations "—the properties of the street surfaces. If we are to concern ourselves with the design of the visual field we are committed to a study of the decorations, for they are a factor at least as important as the lighting equipment. I have advocated elsewhere that some of us should turn into " lighting artists," expert in both the engineering and the aesthetic side; for most of this problem is a problem in aesthetics.

MR. J. B. COLLINS : This paper and discussion have served to emphasise the direction which further research should take. It is essential before considering the recommendations of any actual figures in a code of this kind to consider what we know about these problems and what we do not know. For instance, we know something of what brightness relations cause various degrees of discomfort, but we do not know much about the relations before reaching these conditions. We do not know what causes the concentration of attention, the feelings of stimulation, tiredness or long-term fatigue. It appears that here our physical meters cannot help us as they have done in the days of illuminating engineering, and although we may learn much from encephalographic techniques such as Mr. Stevens mentioned, brightness engineering will mean using the human beings themselves as the meters.

MR. R. L. C. TATE : A great deal of the dissatisfaction which British illuminating engineers find in American brightness engineering practice may be due in part to the climate of each respective country.

I understand that over a great part of the United States the natural sunlight is very much stronger than it is in this country and, therefore, people are subjected to intolerable conditions of glare and heavy shadows. Indoors there is a tendency to use venetian blinds and similar devices to reduce this very high brightness and obtain a diffused type of light with consequent low brightness contrasts.

In this country, on the other hand, we are accustomed to outdoor conditions where the cloudy atmosphere normally gives us low brightness and soft shadows, and we take considerable pleasure in a bright, sunny day when those contrasts are enhanced. To us a room in which brightness contrasts are low suggests a dull, cloudy day, whereas one which has reasonably strong brightness contrasts gives a feeling of pleasure connected with the sort of conditions we associate with brilliant sunshine.

In consequence, the Americans would choose what to us would appear rather a

dull lighting scheme in preference to one which contained areas of relatively high brightness and deeper shadow, since this would conform to their ideas of visual comfort indoors.

MR. C. E. GREENSLADE: Logan's field flux method of lighting design has the advantage that he has gone out into the open. He has made a very large number of measurements and has taken into account the flux from various directions. It is all based on outdoor work; but whether we consider that indoor lighting approximates to outdoor lighting is another matter. On the other hand, I think Logan's brightness ratio has been rather misrepresented. Provided the areas are large enough it will allow a variation of 41 to 1, and a maximum, in fact, of even 48 to 1.

If we look at Logan's scheme the other way round, it is much easier. Take the eye as being the source of light and project these areas on to the ordinary "onion" diagram. It would then not be difficult to draw up a light flux diagram and produce a uniform illumination on a greyish wall. Logan now divides up the field of view and gives the variation that can be allowed in any one of these areas; the sort of thing that would be done in designing a lighting fitting where you want to deflect the light upwards from the horizontal. When we are comparing a part of one area with a part of another area we must compensate to get an average; but the difficulty with Logan's calculations is that the limits are very wide as between the readings in different directions.

MR. ROBINSON (replying to the discussion): One of the most important points raised in the discussion was the possible tendency for the application of brightness engineering to result in uniformity and drabness in an interior. As this point is fundamental to any further progress in the planning of interior brightness distribution it deserves careful consideration. It would be unfortunate if the terms of reference of brightness engineering, as envisaged by the *author*, were to be misunderstood. It is not practicable to consider planning the detailed brightness of all parts of a room and it is not suggested that lighting design should aim at anything more than the attainment of a few very broad relationships between *average* brightnesses of ceiling, upper and lower walls, floor, work and light sources. A wall may be given a certain average brightness while still retaining within it brightness ratios such as exist between an open window at night and a lighted wall. It is difficult, therefore, to see how a 3:1 brightness ratio (or any other) can impose any serious restriction on the decoration or furnishing of the room. It is not even suggested that the curtaining of windows is an essential feature of brightness engineering, though it is recognised by any illuminating engineer as good practice. There seems to be considerable danger that progress towards the extension of present lighting practice to include the generalised flux distribution throughout the entire field of view, which all illuminating engineers accept as a reasonable aim, will be hindered rather than helped by the term brightness engineering if it should become associated with the idea of a revolution in lighting practice, and if it should imply new functions and responsibilities which the average lighting engineer is not in a position to undertake.

Mr. Holmes related the idea of visual comfort and acceptability, which lies at the root of brightness engineering, to dullness and uniformity in a similar way. He pointed out the importance of interest and workability in interior lighting but he did not make clear in what sense the adoption of generalised brightness relationships could in any way destroy these attributes. In his example where a plaster worker suffered ill-health as a result of bad light distribution, he quoted the remedy, which was to even out the balance of flux from different parts of the field of view (i.e., the bulk brightness of large areas of the field), and which is precisely the function of brightness engineering as I understand it. He referred to the fact that Logan, in his field flux method, would expect brightness ratios up to perhaps 50:1 between

one small part of the field and another. I contend that the ratio method of brightness design would permit precisely the same conditions ; and would go further and say that fundamentally a brightness design produced by the field flux method of design would differ from a ratio design only in details, the fundamental feature of both methods being the attainment of a proper balance of the bulk brightness of large areas of the field, the brightness ratios within these large areas being determined by normal functional or aesthetic considerations.

Mr. Holmes was not alone in instancing the inside of an integrating photometer as analogous to a brightness engineered room. To accept that analogy would be to state that brightness engineering was divorced not only from practical lighting engineering but also from common sense. Needless to say the analogy is rejected, as is the suggestion, made in his subsequent reference, that discriminatory contrast is related to brightness ratios. In my view there is no connection between them.

Mr. Waldram referred to lighting for emphasis and modelling and suggested that brightness ratio limitations would apply to the shadow pattern created for modelling purposes.

The reply to this is that generalised brightness ratios were never intended to circumscribe lighting effects. Where there is loss of form or emphasis the fault lies with the decorator, architect and lighting engineer in varying proportions. It would be wrong to blame any generalised lighting code for the failure to interpret it properly.

Mr. Waldram also referred to " lighting artists " and seemed to imply that there could be two types of lighting practitioner, one of whom obeyed the rules and another who broke all the rules. It would be disastrous if we took the line that any cleavage was desirable or even necessary. A good interior demands both satisfactory generalised distribution of light flux, which only lighting engineers can produce, together with aesthetic factors which involve the fullest acceptance of the parts to be played by the engineer and the artist. (This does not preclude the happy circumstance when the engineer *is* an artist.) Lighting must always be a co-operative endeavour. The result is judged in relation to the lighted scene and not on the disposition of the lighting equipment alone and it is hoped that brightness engineering will lead to greater co-operation between all concerned rather than to an artificial inflation of the functions of lighting engineers.

Dr. Hopkinson points out, very rightly, the large amount of fundamental work involved in making brightness engineering possible. It is not my intention to suggest that we are feebly following the Americans. The American work only seems more prominent because it has received more publicity. But I think we shall be wasting our energies if we deal with each of the methods separately. We have to try to synthesise the ideas into some form of brightness code. I have suggested a method of approach but we must not simply go on talking about the difficulties involved. I feel sure that by talking about them we are not going to find the answer, unless at the same time we try to do something about it.

The difficulties of appraisal were mentioned by Mr. Stevens. In this we have rather to take a leap in the dark because if we try to appraise an installation in a rather subtle manner we shall never finally arrive at an appraisal. It is, however, a simple matter to go into a factory and say that the lighting is bad. But we must do something about it. It is quite true that the final judges of the lighting in a room are the people who are working there but we have to be very careful in interpreting their first reactions because if we take too seriously all the comments of people working under new lighting conditions we shall be very greatly led astray. There are very few people who know exactly what is good for them in lighting. It is not necessarily for us to say that we know, but we are trying to find out and, therefore, we must not be too easily discouraged about appraisal. The adoption of a defective code, I

feel, would be better than no code at all but I do not pretend that I am capable, at the moment, of suggesting what it should be.

The difference between illuminating engineering and brightness engineering is, to me, rather entering into metaphysics, because what illuminating engineers are aiming at is the brightness distribution for good lighting. We are not concerned whether that good lighting is called illumination or brightness. We are concerned with good lighting. Illuminating engineering is based fundamentally on the provision of a certain level of brightness on the work, and the brightness engineer is only another illuminating engineer with an eye on the room as a whole. I prefer to make no greater distinction than that.

Another point raised is that comfort may be undesirable because it does not lead to conditions suitable for hard work. I feel fairly certain this was said with the tongue in the cheek because we all know that in talking of productivity the first thing necessary is to make the people concerned comfortable. Comfort is a necessary pre-requisite to good work: whether it is a pre-requisite to hard work is another thing, but it is necessary for effective work. The word "comfort" may be wrongly used. I think we should define it in this instance as the absence of glare and visual fatigue. We want to do the job without visual handicaps.

I support Mr. Ackerley's suggestion that we might as well not only specify a range of average brightnesses, but also deal with the introduction of variety in the lighting which will give interest to a room. Nevertheless, we must be careful not to usurp the function of the architect. The whole point, which I have repeatedly stressed, is that there is no suggestion that the lighting engineer should usurp anyone's function. He should merely provide better lighting and provide conditions whereby the artist and others can do their jobs to the best advantage. To me, brightness engineering in its future form can apply equally well in an art gallery as in a schoolroom.

The danger of falling too much in line with recommended practice has been mentioned. I think the more serious danger is that we never shall have a recommended practice. There is something to be said for both points of view; for the point of view that we should go on refining our lighting methods until there emerges in the end something that we want, or the American approach which is based on the assumption that we should start with a Code of Practice even if it is not quite the right one. The Americans seem to be sure that it will be better than nothing at all, and my own feeling is the same. I feel that a brightness code, however wrong it may be, is better than the present situation. I suggest that something like 90 per cent. of our present lighting will be found to be bad when judged by the standards which we know to be possible.

The possibility that the Americans have been influenced by their climate and consequent difference in interior day-lighting conditions in arriving at their brightness ratios was mentioned by Mr. Tate. There may be something in that and I think that we in this country must accept responsibility for own own brightness ratios. The brightness ratios which have been suggested, in this country as well as in America, are based on a large amount of experimental work—and very important work it is—and I do not think we can ignore it. We must also consider them in relation to what has been found in regard to brightness ratios with natural lighting, although I think there is a serious doubt as to whether the criterion for outdoors is necessarily the right one for indoors.

Mr. Beggs has queried the need for high accuracy in the interreflection tables. Although in some of these tables the change of value with changing reflection factor is small, in others it is much larger. Attention is drawn to the fact that the interreflection tables in the first edition of the American I.E.S. Handbook, to which reference has been made, contain several obvious typographical errors. These will, no

doubt, be corrected in later editions but those proposing to use such tables should verify that they are a corrected set.

The term brightness has been used throughout this paper in view of the generalised nature of the matters discussed and because this term has been largely used up to date by the workers on whose reports the paper is based. It is pointed out, however, that the term "Luminance" has been internationally agreed for photometric brightness. with which this paper is mainly concerned.

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

With a view to avoiding possible confusion with other publications, reference to these Transactions should be in the form :—"Trans. Illum. Eng. Soc. (London)."

Report Of The Council

(January 1 to December 31, 1950)

The present Annual Report of the Council deals with the year ended on December 31, 1950, being the forty-second year of the Society's activities. Exceptional events during the year were the adoption of amendments to the Articles of Association and the organisation of a lighting exhibition in London as a feature of the International Congress of Ophthalmology. The year was also signalised by the Second Summer Meeting of the Society but, apart from these events, it was also a satisfactory year in respect of the regular activities of the Society as well as by reason of continued growth of membership.

Officers, Council and Standing Committees for Session 1950-51

In conformity with the procedure laid down in the Articles and By-laws of the Society, nominations made by the Council to fill vacancies for the session 1950-51 were circulated to Corporate Members, who were given an opportunity to make additional nominations. No new nominations were received and the proposals of the Council accordingly became effective, the following being elected:—

President: Mr. L. J. Davies.
Vice-Presidents: Mr. C. R. Bicknell, Mr. J. G. Holmes, Mr. W. R. Stevens.
Hon. Treasurer: Mr. W. J. Jones.
Hon. Secretary: Mr. H. C. Weston.
Hon. Editor of the Transactions: Dr. W. E. Harper.
Ordinary Members of Council:—Mr. G. G. Baines, Mr. S. S. Beggs, Dr. W. E. Harper, Mr. A. G. Higgins, Mr. L. H. McDermott, Mr. A. G. Penny, Sir Henry Self, Mr. W. J. P. Watson.

Owing to the resignation from Council of Mr. J. N. Hull, who has taken up an appointment in New Zealand, a casual vacancy for a period of two years was caused. At their first meeting in October the Council, acting in accordance with Article 50, appointed Dr. R. G. Hopkinson to fill this casual vacancy.

At the beginning of the year it became apparent that certain changes would need to be made in the Memorandum of Association in order to confirm the position of the Society as a charitable organisation for purposes of Inland Revenue. Whilst making these changes the Council took the opportunity of suggesting changes in the Articles of Association regarding the number and period of service of Vice-Presidents in order to enable this honour to be offered to a greater number of members who have ably served the Society and who might not otherwise receive adequate recognition. The proposed amendments to the Memorandum and Articles of Association were therefore submitted to the members and approved at an extraordinary general meeting held on March 14. Previously the number of Vice-Presidents was limited to three and service in this capacity was limited to a period of not more than three years in succession. Under the amended Articles the Council may appoint up to five Vice-Presidents, the period of service being not more than two years in succession. No change in the number of Vice-Presidents was, however, made during the session 1950-51.

The following were appointed to represent their respective Centres on the Council for the session 1950-51.

Bath and Bristol: Mr. H. J. Weston. *Birmingham*: Mr. F. Penson. *Cardiff*: Mr. D. C. James. *Edinburgh*: Mr. H. D. Purvis. *Glasgow*:

To be presented at the Annual General Meeting of the Society to be held at the Royal Institution, Albemarle Street, London, at 6.0 p.m. on Tuesday, May 8, 1951.

Mr. F. Dunnett. *Gloucester and Cheltenham*: Mr. I. R. Morgan. *Leeds*: Mr. J. W. Howell. *Leicester*: Mr. R. K. L. Davies. *Liverpool*: Mr. T. D. Woods. *Manchester*: Mr. W. G. Chilvers. *Newcastle*: Mr. J. S. McCulloch. *Nottingham*: Mr. G. C. Small. *Sheffield*: Mr. J. A. Whittaker.

The attendance of ordinary members of the Council and representatives of Centres at Council meetings during the year is given in the accompanying table. It is pointed out that a Centre may be represented on Council by the Chairman of the Centre Committee or by any other representative nominated by the committee. Owing to the session beginning in October a Centre may be represented during the calendar year by two chairmen or by such other representatives as appointed by the Centre Committee. The attendance figures for the Centres do not, therefore, refer to individuals.

Attendance at Council Meetings

(a) NOMINATED MEMBERS OF COUNCIL

Name	Possible attend.	Actual attend.	Name	Possible attend.	Actual attend.
A. D. S. Atkinson	8	6	B. F. W. Besemer	5	3
H. S. Barlow	8	2	H. Bright	5	1
S. S. Beggs	8	8	J. N. Hull	5	5
H. G. Campbell	8	7	J. H. Nelson	5	0
W. J. Wellwood Ferguson	8	1	J. S. Smyth	5	1
G. H. Giles	8	2	J. F. Stanley	5	3
H. F. Gillbe	8	0	P. C. Sugg	5	4
C. A. Hoskins	8	6	E. Wood	5	4
A. W. Jervis	8	2	G. G. Baines	3	0
E. C. Lennox	8	3	W. E. Harper	3	3
L. C. Rettig	8	5	A. G. Higgins	3	1
E. B. Sawyer	8	7	L. H. McDermott	3	1
W. T. F. Souter	8	4	A. G. Penny	3	3
W. S. Stiles	8	5	Sir Henry Self	3	0
D. A. Strachan	8	4	W. J. P. Watson	3	3
S. G. Turner	8	1	R. G. Hopkinson	2	2

(b) REPRESENTATIVES OF CENTRES

Bath and Bristol	8	4	Leeds	8	6
Birmingham	8	6	Leicester	8	3
Cardiff	8	1	Liverpool	8	6
Edinburgh	8	0	Manchester	8	3
Glasgow	8	0	Newcastle	8	3
Gloucester and Cheltenham	8	0	Nottingham	8	1
			Sheffield	8	7

Committees

The Standing Committees as from October, 1950, were constituted as follows:—

GENERAL PURPOSES COMMITTEE: L. J. Davies (*President*), C. R. Bicknell, J. G. Holmes, W. R. Stevens (*Vice-Presidents*), W. J. Jones (*Hon. Treasurer*), H. C. Weston (*Hon. Secretary*), J. N. Aldington (*Past-President*), J. W. Howell (*Leeds Centre*), G. C. Small (*Nottingham Centre*).

PAPERS COMMITTEE: A. D. S. Atkinson, H. G. Campbell, W. E. Harper, J. G. Holmes, R. G. Hopkinson, W. T. F. Souter, W. S. Stiles, J. M. Waldram (Chairman). *Co-opted*: L. H. Hubble, C. J. Misselbrook.

EDUCATION COMMITTEE: R. O. Ackerley (Chairman), G. G. Baines, H. S. Barlow, S. S. Beggs, A. Cunnington, W. J. Jones, J. T. MacGregor-Morris, F. C. Smith, W. R. Stevens, J. W. T. Walsh.

I.E.S. CODE COMMITTEE: R. O. Ackerley, E. B. Sawyer, F. C. Smith, W. T F. Souter, W. S. Stiles, H. C. Weston (Chairman).

CENTRES JOINT COMMITTEE: One representative from each Centre. Council's Representatives: C. R. Bicknell, E. B. Sawyer, W. R. Stevens.

The Development Committee, having dealt with the major problems before it,

was discontinued at the beginning of the Session, its remaining functions being allocated to other Standing Committees.

The Council wish to record their thanks to members who have given their time and assistance on committee work during the year.

Meetings in London

Seven sessional meetings were held in London during the year. Details of these are given in the table.

DATE	SUBJECT	AUTHOR
January 10th	Discomfort Glare in Relation to the Lighting of Buildings	R. G. Hopkinson and P. Petherbridge
February 14th	The Dimming of Fluorescent Lamps and its Application to the Theatre	J. W. Strange
March 14th	Acrylic Enclosures for Flameproof Lighting Equipment	W. E. Harper and P. H. Collins
April 11th	Visual Aids for Landing in Bad Visibility with Particular Reference to the Transition from Instrument to Visual Flight.	E. S. Calvert
October 10th	Presidential Address.	L. J. Davies
November 14th	The Lighting of the New House of Commons	C. Dykes Brown
December 12th	The Development of the Tungsten Lamp.	B. P. Dudding

The good attendance at sessional meetings and the high standard of discussion were well maintained.

The practice of including informal meetings and visits in the London programme was continued. Informal meetings included a series of talks on lighting in other countries and a discussion on a number of interesting lighting problems. A visit was made to the Building Research Station at Garston. The Council take this opportunity of expressing their thanks to those members and others who have helped to arrange meetings and visits, and to those organisations which have extended their hospitality to the Society both in London and in the Centres and Groups.

Activities of Centres and Groups

Programmes of meetings and visits at Centres and Groups were well maintained, and in a number of cases outstanding attendances were achieved. A number of Centres have continued the practice of holding annual social functions in the form of a luncheon, dinner or dance, and other Centres have now adopted this procedure with success. On such occasions the opportunity is taken of inviting representatives of the local civic authorities and other societies and institutions, a practice which helps considerably to strengthen the status of the Centre.

A number of Centres have also played a leading part in connection with other local functions, such as the public lectures given in Liverpool and Nottingham by Dr. J. N. Aldington and Mr. L. J. Davies respectively when the local Centre assisted in the organisation and arrangements.

The Leed Centre collaborated with the Wool Industries Research Association, who organised a three-day exhibition of colour-matching equipment, which was very well attended by representatives of the wool industry and others, and from which, by means

of tests carried out during the course of the exhibition, some useful information on the preferences of various operatives in regard to colour-matching lamps was obtained.

During the year the majority of Centres were visited by the President, sometimes accompanied by the Secretary. As in the past most of these visits have taken place in the latter part of the session. Dr. Aldington, at the Annual General Meeting in May, asked Centres to help the President by spreading the visits throughout the session and, in addition, to send their invitations to the President as early as possible. During the last half of the 1949-50 session Dr. J. N. Aldington visited Centres at Bath and Bristol, Birmingham, Cardiff, Glasgow, Leeds, Liverpool, Manchester and Newcastle. During the first part of the 1950-51 session, Mr. Davies had by the end of the year visited the Centres at Manchester, Leeds, Nottingham and Leicester; other Centres will be visited by the President during the remainder of the session.

A number of Centres have made use of the standard lecture and demonstration equipment in lectures to school children. A number of educational authorities have expressed their appreciation of this aspect of the Society's activities.

The Council would acknowledge the work during the year of the Secretaries of the various Centres; it is appreciated that the success of a Centre's activities depends largely on the work put in by the local Secretary. The Secretaries of the various Centres during the year were as follows:—

Bath and Bristol: Mr. R. S. Hazell; *Birmingham*: Mr. W. J. P. Watson; *Cardiff*: Mr. W. A. Cooper; *Edinburgh*: Mr. G. E. L. Comrie; *Glasgow*: Mr. A. M. Rankin; *Gloucester and Cheltenham*: Mr. F. J. Chappell; *Leeds*: Mr. R. D. Green; *Leicester*: Mr. B. V. Rowe; *Liverpool*: Mr. K. R. Mackley; *Manchester*: Mr. W. E. Ballard; *Newcastle*: Mr. A. E. Ward; *Nottingham*: Mr. A. R. Law; *Sheffield*: Mr. E. G. R. Taylor.

Summer Meeting

Following the success of the Society's first Summer Meeting at Harrogate in 1948 a further Summer Meeting was held at Buxton from May 16 to 19. The high standard set at the Harrogate meeting was well maintained and many members from all parts of the country as well as a number of visitors from overseas attended. The meeting was organised by the Summer Meeting Committee which included representatives of the Manchester Centre which was responsible for the local arrangements. Considerable help was received from the North Western Electricity Board and from Mr. P. Corry who was responsible for the stage management in connection with the presentation of the papers.

In order to give adequate time for full discussion of the papers the programme was arranged so that only one paper was presented during each morning or afternoon. After a civic reception on the evening of May 16 by the Mayor of Buxton the meeting opened the following morning with a lecture on "Visual Deception" by Dr. L. A. Sayce of the National Physical Laboratory. Subsequent papers were "Floodlighting" by R. O. Ackerley; "Lighting of Fibre and Fabric" by H. Hewitt; "Stage Lighting in the Post-War Theatre in Great Britain" by L. G. Applebee, and "The Development of Street Lighting in Great Britain" by J. M. Waldram. Following the Annual General Meeting, which formed part of the proceedings, an address on "Lighting in Sweden, 1940-50" was given by Mr. Ivar Folcker, President of the I.E.S. of Sweden. Social events in addition to the opening civic reception included the President's reception, a mannequin parade, and a visit to Haddon Hall for the ladies and a tour of the Derbyshire Dales. A further competition for the Dow Golf Cup was arranged.

In view of the success of the first two meetings of this kind held by the Society attention is now being given to arrangements for a further meeting to take place in 1952.

The Council express their appreciation of the work done by the members of the various committees and others in connection with the Buxton meeting.

Lighting Exhibition

In July, 1950, the sixteenth International Congress of Ophthalmology was held in London and, at the request of the Executive Committee, the Society arranged a Lighting Exhibition at the London School of Hygiene. The exhibition was well attended by delegates from all parts of the world who were much interested in the exhibits illustrating fundamental principles of good lighting, as well as those illustrating modern lighting practice. The cost of the exhibition was borne almost entirely by the British Electrical Development Association and the Electric Lamp Manufacturers' Association. The Council wish to thank these sustaining members for their action in this matter, as well as to thank the Panel appointed by the Council to plan and organise the exhibition.

Publications

Ten issues of the Transactions were again made during the year. Though, as mentioned in the Report for 1949, the number of papers submitted for presentation or for publication is less than might be desired, the number of pages in the 1950 volume was again more than in the previous year, being 360 for 1950 compared with 322 in 1949 and 266 in 1948. The Papers Committee are taking steps to encourage the submission of papers to the Society but it does not follow that any noticeable increase in the size of the Transactions will be immediately apparent; the amount of original work justifying publication by the Society is not unlimited, whilst some limitation on the number of pages which can be published is imposed by financial considerations and by the continuing shortage of paper.

The following contributions, in addition to the papers presented at sessional meetings in London and at the Summer Meeting, were published in the Transactions during the year: "A Polar Distribution Calculator" by H. V. Shurmer; "Cinema Auditorium Lighting" by J. S. Smyth; "Air-cooled High Intensity High Pressure Mercury Vapour Lamps" by V. J. Francis, and "Special Lighting Units for the Flight Decks of Aircraft Carriers" by H. H. Mathews.

The edition of the I.E.S. Code which was issued in 1949 continued to be in demand, and it is apparent from the inquiries which continue to be received that the Code has made a considerable impression both in this country and overseas.

Towards the end of 1949 discussion took place with the Illuminating Engineering Publishing Company, Ltd., concerning possible improvements to the journal *Light and Lighting*, which is sent to all members. It was understood from representatives of the publishing company that improvements in the journal had been under consideration for some time, though, owing to paper shortage and financial considerations, it had been possible to make only limited improvements. At the request of the Society, however, the publishing company agreed to introduce further improvements which they had in mind from the beginning of 1950. As a result of this, during the year under review, the journal has taken on a much improved appearance both in content and layout and the Council would like to take this opportunity of expressing their appreciation to the Illuminating Engineering Publishing Company, Ltd., for their co-operation in this matter.

The Council would point out, however, that the improvements which have been made, and further improvements which the publishing company would like to make in due course, greatly increase the cost of production of the journal which must be balanced by increased income. One way in which the necessary increase in income can be achieved is by enlarging the circulation outside the Society which, if sufficient, would enable the publishing company to meet the rising cost of production without further increasing the cost to the Society. The Council, therefore, ask members to help encourage the circulation of *Light and Lighting* by drawing it to the notice of electrical engineers, electrical contractors, architects, etc. In this way members would

not only be helping the Society directly, but would also be actively assisting in one of the objectives of the Society, which is to disseminate knowledge and information on lighting matters. It is of some interest to note that steps already taken in this direction have resulted in obtaining many new members for the Society.

Leon Gaster Memorial Premium

This year the Leon Gaster Memorial Premium, offered for the best paper contributed and published during the session, was awarded to Mr. P. Petherbridge and Dr. R. G. Hopkinson for their paper entitled "Discomfort Glare in Relation to the Lighting of Buildings."

For the first time for several years an application was received for the Silver Jubilee Commemoration Award and the award was made to Mr. I. R. Hall for an essay entitled "Some Physical Problems Associated with the Development of the Fluorescent Lamp." The younger members of the Society, for whom the award was instituted, are reminded that full details of the award may be obtained from the Secretary, and other members of the Society are asked to give every encouragement to junior members to make application for this award.

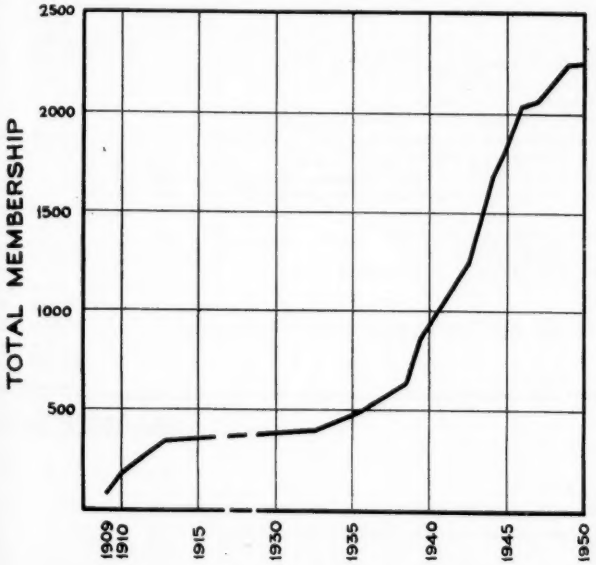

Fig. 1. Showing the growth of membership of the Society.

Membership

The additions to membership during the year were as follows:—

Corporate Members	260
Associates and Country Members	5
Students	27
Sustaining Members	6

Due to resignations, etc., the increase over the year is only small. It is interesting to note the growth of membership since the Society was founded in 1909 and this is shown on the accompanying chart. Though the steady rise of the last few years

INCOME AND EXPENDITURE ACCOUNT

1949 £	EXPENDITURE.	£ s. d.	£ s. d.
	Administration Expenses :—		
1,928	Salaries and State Insurance	2,068 6 5	
344	Rent and Rates	357 2 6	
49	Lighting and Heating	61 7 11	
81	Telephone	86 5 2	
584	Printing and Stationery	447 3 0	
253	Postage	202 19 4	
118	Travelling Expenses	59 15 2	
300	Sundry Office Expenses	390 1 5	
			3,673 0 11
176	Meetings in London		125 10 6
1,073	Expenditure of Centres and Groups		1,120 13 0
26	Audit Fee		26 5 0
4,932			4,945 9 5
1,303	Cost of Printing Transactions, Reprints, etc.		1,337 3 5
125	Cost of Printing List of Members		– – –
40	Equipment for School Lectures		– – –
34	Expenditure on Annual Dinner *less* Sale of Tickets ...		– – –
	Expenditure on Summer Meetings *less* Sale of Tickets		91 7 5
	Illuminating Engineering Publishing Co., Ltd.—		
	Allocation and Share of Subscriptions	1,035 12 0	
441	*Less* Contribution towards administration ...	500 0 0	
			535 12 0
48	Contributions to Kindred Societies		58 5 0
132	Premiums on Deferred Annuities		132 6 4
5	Transfer to Leon Gaster Memorial Fund		– – –
7,060			7,100 3 7
669	Excess of Income over Expenditure		604 16 7
£7,729			£7,705 0 2

BALANCE SHEET

1949 £		£ s. d.	£ s. d.
	Capital Account :—		
	Balance at 31st December, 1949	6,067 12 4	
	Add Excess of Income over Expenditure for the year	604 16 7	
6,068			6,672 8 11
1,000	Reserve for Future Office and Administration Expenses ...		1,000 0 0
502	Creditors		311 4 9
£7,570			£7,983 13 8

W. J. JONES (*Hon. Treasurer*)
H. C. WESTON (*Hon. Secretary*)

Auditors' Report.—We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purpose of our Audit. In our opinion proper books of account have been kept by the Society so far as appears from our examination of those books. We have examined the above Balance Sheet and annexed Income and Expenditure Account and Fund Receipts and Payments Accounts which are in agreement with the books of account. In our opinion and to the best of our information and according to the explanations given to us the said accounts give the information required by the Companies Act

FOR THE YEAR ENDED 31st DECEMBER, 1950

1949 £	INCOME.	£ s. d.
6,553	Subscriptions and Fees	6,826 19 3
980	Sales of publications	632 13 7
174	Interest on Investments	205 14 6
—	Income Tax recoverable in respect of previous years	39 12 10
22	Transfer from Library Fund	– – –
£7,729		£7,705 2

31st DECEMBER, 1950

1949 £		£ s. d.	£ s. d.
	Investments at cost :—		
	£2,020 14s. 7d. 3½% Registered War Stock ...	2,059 15 0	
	£ 250 3% Defence Bonds	250 0 0	
	£2,250 2½% Defence Bonds	2,250 0 0	
	£ 750 2½% National War Bonds ...	750 0 0	
	£1,500 3% Savings Bonds...	1,501 15 3	
	£ 500 3% British Transport Guaranteed Stock	488 4 6	
	(*Market Value 31.12.50*, £7,097)		
6,798			7,299 14 9
677	Balance at Bankers and Cash in Hand		545 6 4
95	Debtors, including Income Tax recoverable		138 12 7
£7,570			£7,983 13 8

1948 in the manner so required and the Balance Sheet gives a true and fair view of the state of the Company's affairs as at 31st December 1950 and the Income and Expenditure Account gives a true and fair view of the surplus for the year ended on that date.

ROBERT J. WARD & CO., *Chartered Accountants*,
ADELPHI TERRACE HOUSE, 3, ROBERT STREET, ADELPHI, W.C.2.

Dated this 31st Day of January, 1951.

RECEIPTS & PAYMENTS ACCOUNTS

LEON GASTER

1949		£ s. d.
£		
243	Balance, 1st January, 1950	245 11 4
8	War Stock Interest	8 1 0
5	Transfer from General Fund	– – –
£256		£253 12 4

NATIONAL ILLUMINATION

£		£ s. d.
307	Balance, 1st January, 1950	317 12 9
10	War Stock Interest	10 10 0
£317		£328 2 9

INTERNATIONAL ILLUMINATION

£		£ s. d.
401	Balance, 1st January, 1950	412 0 6
11	War Stock Interest	10 10 0
£412		£422 10 6

TROTTER-PATERSON

£		£ s. d.
6	Balance, 1st January, 1950	225 10 6
220	Donations	179 1 0
£226		£404 11 6

JOHN S. DOW

£		£ s. d.
1,948	Legacy bequeathed by the late Mr. John S. Dow	– – –
—	Balance, 1st January, 1950	1,945 3 6
16	Interest on Investments	48 11 6
£1,964		£1,993 15 0

FOR THE YEAR ENDED 31st DECEMBER, 1950

MEMORIAL FUND

1949		£ s. d.	£ s. d.
£			
10	Premiums paid for 1950/51		10 10 0
	Balance, 31st December, 1950 :—		
	Cash at Bank	6 9 2	
	£230 3½% Registered War Stock at cost	236 13 2	
	(*Market Value 31.12.50*, £217)		
246			243 2 4
£256			£253 12 4

COMMITTEE FUND

£		£ s. d.	£ s. d.
	Balance, 31st December, 1950 :—		
	Cash at Bank	23 14 3	
	£300 3½% Registered War Stock, at cost	304 8 6	
317	(*Market Value 31.12.50*, £283)		328 2 9
£317			£328 2 9

CONGRESS FUND

£		£ s. d.	£ s. d.
	Balance, 31st December, 1950 :—		
	Cash at Bank	118 2 0	
	£300 3½% Registered War Stock, at cost	304 8 6	
412	(*Market Value 31.12.50*, £283)		422 10 6
£412			£422 10 6

MEMORIAL LECTURE FUND

£		£ s. d.
	Balance, 31st December, 1950 :—	
226	Cash at Bank	404 11 6
£226		£404 11 6

LEGACY FUND

£		£ s. d.	£ s. d.
19	Legal Expenses		– – –
	Balance, 31st December, 1950 :—		
	Cash at Bank	147 10 0	
	£916 11s. 1d. 3½% War Stock	876 5 0	
	£500 3% Savings Bonds, 1955/65	492 10 0	
	£500 3% Savings Bonds, 1960/70	477 10 0	
1,945	(*Market Value 31.12.50*, £1,864)		1,993 15 0
£1,964			£1,993 15 0

has not continued during 1950 it is perhaps not too optimistic to hope that the Society might reach a membership of 2,500 by the end of 1952.

It is with regret that the Council record the death during the year of two distinguished members of the Society, namely, Mr. Dean Chandler, who over many years had been responsible for many important developments in gas lighting, and

TOTAL MEMBERSHIP (December 31, 1950)

	Fellows	Corporate Members	Country Members	Associates	Students	TOTAL	Sustaining Members
London	88	544	1	8	20	661	42
Centres :—							
Bath & Bristol...	4	57	—	9	—	70	3
Birmingham ...	13	210	—	5	11	239	22
Cardiff	3	69	—	1	1	74	1
Edinburgh ...	4	41	—	—	—	45	3
Glasgow ...	5	66	1	—	—	72	2
Gloucester & Cheltenham ...	—	35	—	—	9	44	—
Leeds	5	102	—	2	7	116	4
Leicester ...	1	44	—	—	—	45	—
Liverpool ...	1	114	—	—	2	117	7
Manchester ...	6	156	—	1	—	163	7
Newcastle ...	3	95	—	3	—	101	4
Nottingham ...	5	66	—	1	—	72	1
Sheffield ...	2	62	—	—	1	65	2
Groups :—							
Bradford ...	1	31	—	1	—	33	—
Exeter	1	27	—	—	—	28	2
Huddersfield ...	1	35	—	1	—	37	—
Stoke-on-Trent	—	31	—	—	—	31	—
Sussex	5	23	—	1	—	29	1
Swansea ...	—	26	—	—	—	26	—
Teeside ...	1	23	—	—	—	24	—
Ireland	2	17	8	1	1	29	1
Overseas ...	12	73	44	2	—	131	2
TOTAL ...	163	1947	54	36	52	2252	104

Mr. Percy Good, who was a past-president of the Society and who played such an important part in promoting international collaboration in advancing the art and science of lighting and in the work of standardisation.

Four new Fellows were elected during the year, the total number of Fellows now being 163.

The Society is permitted under the constitution to elect one Honorary Member each year up to a maximum of six. Until recently this honour had only twice been awarded, to Mr. A. P. Trotter and Mr. J. S. Dow. Last year Mr. Howard Long was made an Honorary Member in recognition of the services he has rendered in the promotion of the growth and development of the Society. At the Annual General Meeting of the Society in May it was announced that Honorary Membership had been

conferred upon Dr. Ward Harrison in acknowledgement of his numerous and valuable contributions to the advancement of the art and science of lighting and in recognition of the eminence he has attained. The President, Mr. L. J. Davies, was able later in the year whilst visiting the United States of America to take the opportunity of personally presenting the citation to Dr. Harrison.

Register of Lighting Engineers

When the Register of Lighting Engineers was introduced in 1947 it was made clear that those wishing to claim exemption from the City and Guilds intermediate examination in illuminating engineering must do so within two years. This period expired on February 1, 1950, after which date all applicants were required to take the examination. In drawing up the revised regulations other alterations were made, including an increase in the period of practice from three to five years and the introduction of a minimum age qualification. Many members wishing to be included on the register without the full educational qualifications made their applications only shortly before the end of the stated period. As a result the Registration Board received over a hundred applications. As each application has to be thoroughly examined there was some delay in dealing with all applications, but by the end of the year the Registration Board had dealt with the majority. The task of the Board has been very difficult and the Council express their thanks to the members of the Board for the time which they have given to the consideration of applications and for the way they have carried out their duties.

By the end of the year 308 applications had been considered by the Board with results as follows :—

Applicants included on the Register	212
Applications rejected	77
Applications deferred	19
Applications awaiting attention	3

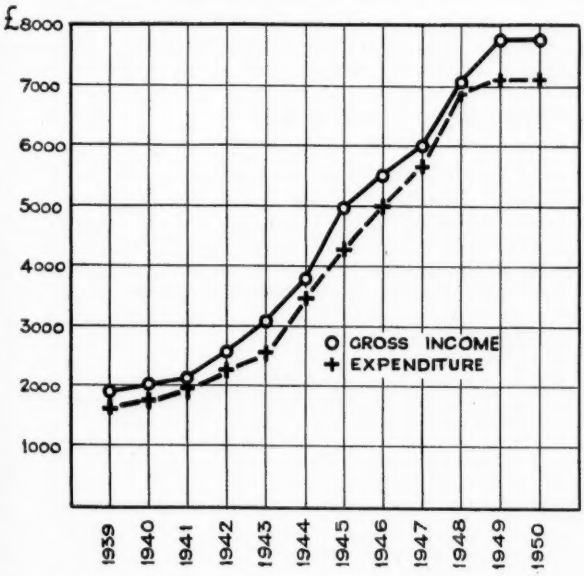

Fig. 2. Showing the increase of income and expenditure of the Society during recent years.

Education

During the year courses for the City and Guilds of London Institute examinations in illuminating engineering were held in London at the Borough and Northampton Polytechnics, and in Cardiff, Liverpool, Manchester, Leeds and Glasgow. Results of the examinations held in May showed 47 successes in the Intermediate grade, 12 in the Final section "A," and 26 in the Final section "B." This shows a drop in the passes in the Intermediate grade for the second year in succession. The number taking the Final examinations varies each year, but it is felt that the number would greatly increase if courses were available for the students. Courses are generally only available in London, whereas the students who have taken the Intermediate examination, who it is thought would be prepared to carry on with a further year's study to pass the Final, are scattered throughout the country. Where a nucleus of students does exist it is found that there is no one available who is qualified to organise the course. The Education Committee are giving serious consideration to this matter and, though it is felt that the organisation of courses in various parts of the country for the Final examinations presents too many difficulties there is a possibility that a suitable correspondence course might be made available.

Financial Position

The income and expenditure of the Society show only a slight change from last year. Income from subscriptions continues to increase though income from sales of publications is lower than during the previous year, when a new and popular edition of the I.E.S. Code was issued. It is interesting to compare the growth of membership of the Society, shown elsewhere in this report, with the graphs of income and expenditure over the last few years. The similarity between the graphs will at once be apparent. Income must naturally rise with an increase in membership, but the graphs show that expenditure rises in approximately the same proportion. Though income has managed to keep just ahead of expenditure there is no indication that a large increase in membership will result in a corresponding increase in the Society's financial reserves or that the Society would be able to broaden its activities substantially. The Society's budget is at present balanced with but a small surplus in hand, but if additional activities or responsibilities are to be undertaken, then it will become necessary to increase income by such means as may be appropriate.

Conclusion

In their preceding Annual Report the Council expressed their confidence of continuance of vigour in the life of the Society during the year now reported upon. The present Council feel that this confidence has been justified fully, and they take this opportunity of thanking all those members of the Society who, in London and in the Provincial Centres, have given liberally of their time and counsel in the interests of the Society. The Council are also glad to place on record their appreciation of the loyal services of the headquarters staff.

L. J. DAVIES (*President*).
H. C. WESTON (*Hon. Secretary*).

Additions to List of Members

The following applicants have been duly elected by the Council to membership in the Society, and their names have been added to the list of members:—

SUSTAINING MEMBERS:—

*Humber, Ltd. ..... *Representative*: C. G. Asprey
Ryton-on-Dunsmore, Nr. Coventry, Warwicks.

Tarslag, Ltd. ..... *Representative*: L. P. d'Albuquerque.
Economac House, Dunstal Road, Wolverhampton.

CORPORATE MEMBERS:—

Allenby, G. W. .....4, Oakwood Park, LEEDS, 8.
Barrett, F. H. .....78, Glenpark Road, Ward End, BIRMINGHAM, 8.
Berry, G. .....Council House, Coventry, WARWICKS.
Briske, R. S. .....Willow Haye, Main Street, Menston-in-Wharfedale, LEEDS.
Burton, W. H. .....5, Endcliffe Croft, Endcliffe Vale Road, SHEFFIELD, 10.
Grow, F. H. .....Ashworths Chambers, 5, Prospect Crescent, Harrogate, YORKS.
Cumming, H. W. L. .....36, Broadgate, Preston, LANCS.
Dodgson, J. A. .....The Craigpark Electric Cable Co., Ltd., 55, St. Paul's Street, LEEDS, 1.
Edwards, G. O. .....Oak Tree Cottage, Newton Road, Gt. Barr, BIRMINGHAM, 22a.
Fahey, G. .....The Little House, Elm Road, Bishop's Stortford, HERTS.
Faulkner, L. W. .....21, Aster Road, LIVERPOOL, 14.
Ferguson, H. M. .....47, Donovan Avenue, Muswell Hill, N.10.
Fothergill, R. J. .....60, Stockton Road, West Hartlepool, Co. DURHAM.
French, J. J. .....97, Poplar Walk Road, LONDON, S.E.24.
Gray, I. B. .....c/o Falks Electrical Supplies (S.A.) (Pty.), Ltd., 29, Loveday Street, Johannesburg, S. AFRICA.
Harding, N. W. .....51, Woodhill Crescent, Kenton, Harrow, MIDDLESEX.
Henderson, S. T. .....35, Syke Cluan, Iver, BUCKS.
Holden, A. C. .....25, Greenhill Road, Blackheath, BIRMINGHAM.
Holt, R. S. .....11, Daybrook Street, Sherwood, NOTTINGHAM.
King, J. A. C. .....The Technical Institute, c/o Anglo-Iranian Oil Co., Ltd., Abadan, S. PERSIA.
Jones, F. M. .....8, Dene Road, Whitchurch, Nr. BRISTOL.
Jones, R. A. .....5, Belmont Grove, Lewisham, S.E.13.
Marsh, J. B. ....60, Glen Rise, Billesley, BIRMINGHAM, 14.
Moss, D. .....108, Kent Street, Upper Gornal, via Dudley, WORCS.
McCall, R. W. .....22, Sylvan Road, Upper Norwood, S.E.19.
McKenzie, W. E. .....29, Heath Park Avenue, Cardiff, GLAM.
Nicholas, H. G. .....11, Kirkway, Greasby, Wirral, CHES.
Nutkins, P. A. .....267, Monega Road, Manor Park, E.12.
Palmer, R. C. C. .....4, The Heath, Chaldon, nr. Caterham, SURREY.
Potts, E. L. J. .....8, Polwarth Drive, Gosforth, NEWCASTLE-ON-TYNE, 3.
Rennolf, K. .....31, Elcho Street, LEEDS, 11.
Sambrook, W. L. .....1, Edward Street, Griffithstown, Pontypool, MON.
Seal, F. .....42a, Shakespeare Road, Shirley, BIRMINGHAM.
Simpson, J. T. .....Sunco House, Carliol Square, NEWCASTLE-ON-TYNE.
Smith, F. .....25, Abbeydale Park Crescent, Totley Rise, SHEFFIELD.
Smith, H. S. .....8, South Gardens, The Avenue, Wembley Park, MIDDX.
Still, D. C. .....16, Draycott Road, Ensbury Park, Bournemouth, HANTS.
Turtle, R. .....110, Preston New Road, Blackburn, LANCS.
Wadham, V. J. .....Athan House, Charles Place, Barry, GLAM.
Waigh, D. T. .....141, Cherrydown Avenue, Chingford, E.4.
Webb, L. S. .....116, Glendower Road, Perry Barr, BIRMINGHAM.
Westin, D. .....14, le Marchant Avenue, Huddersfield, YORKS.
White, L. H. A. .....22, Keswick Avenue, Kingston Vale, S.W.15.
Wire, G. H. .....32, Rosslyn Crescent, Wembley, MIDDX.
Womersley, W. .....1, Fairy Dell, Manor Park, Cottingley, nr. Bingley, YORKS.
Woods, H. P. .....34, Mayfair Avenue, Chadwell Heath, ESSEX.

STUDENT MEMBERS:—

Bullock, J. R.	11, Yerbury Grove, Farley Road, Erdington, BIRMINGHAM, 23.
Carpenter, P. A.	92, Summers Lane, North Finchley, N.12.
Dearden, R.	59, Green Hill Road, Middleton Junction, MANCHESTER.
Doo, S. A.	16, Poolsford Road, Colindale, N.W.9.
Holdsworth, E. C.	18, North Avenue, Stafford, STAFFS.
Hoyle, B. K.	48, Oswald Street, Rochdale, LANCS.
Jackson, D. P.	107, The Fairway, Palmers Green, N.13.
Manning, A. A.	24, Fleetwood Avenue, Westcliff-on-Sea, ESSEX.
Matthewman, W.	c/o 79, Somerset Road, Farnborough, HANTS.
Matthews, P. A.	473, Oakwood Lane, LEEDS, 8.
Newling, R. I.	8, Foresters Drive, Wallington, SURREY.
Overton, G. E.	682, Kings Road, Kingstanding, BIRMINGHAM, 22c.
Robinson, A.	60, Amberton Lane, LEEDS, 8.
Scott, J. C.	c/o Hawthorne, 15, Gillian Close, Aldershot, HANTS.

TRANSFERRED TO CORPORATE MEMBERSHIP:—

Ashworth, F.	17, St. Wilfrids Grove, LEEDS, 8.
Cruxton, D. C.	25, Broad Road, Acocks Green, BIRMINGHAM, 27.
Moody, A. H.	68, Clayton Avenue, Wembley, MIDDX.
Pritchard, D. C.	8, Dingwall Road, Croydon, SURREY.
West, H.	26, Huddleston Road, Tufnell Park, N.7.

TRANSFERRED TO COUNTRY MEMBERSHIP:—

Chuck, H. L.	c/o British General Electric Co., Ltd., Magnet House, Corner Loveday and Anderson Streets, Johannesburg. S. AFRICA.

Fellowship

The Council have accepted the following application for Fellowship of the Society:—

D. A. Strachan

Register of Lighting Engineers

The Council have accepted the following applications for inclusion in the Register of Lighting Engineers:—

K. A. Bromley, S. A. Cook, P. J. Hobbs, S. N. Jeffrey, Howard Long, K. Marshall, G. Newnham, J. Prickett, E. T. Radford, R. Rigg, F. Thomas, R. P. Wingate.

Notice of Annual General Meeting

The annual general meeting of the Illuminating Engineering Society will be held at the Royal Institution, Albemarle-street, London, W.1, at 6 p.m. on Tuesday, May 8, when the report of the Council and the accounts for the past year will be submitted.

Binders for Transactions

A limited supply of spring-back binders for the Transactions is now available, price 6s. 6d. each. They may be obtained from the Secretary, 32, Victoria-street, London, S.W.1.

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